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(54) **Induction loop driving amplifier**

(57) An audio frequency amplifier particularly for an induction loop system 19 wherein the input to said amplifier, consisting of stages 17, 18, includes a variable cut-off low pass filter 13. This filter controls the bandwidth of the amplifier in response to the detection of conditions approaching overloading of the amplifier by high amplitude high frequency signal components in such a manner as to reduce the high frequency response of the amplifier during periods when said high amplitude high frequency signal components might otherwise overload the amplifier. The filter 13 is controlled by a signal derived from the output of the amplifier 18, and fed via overload sensor 21 and time constant 22. The arrangement avoids resultant distortion of the amplifier output signal and also avoids the generation of radio frequency interference signals in the induction loop 19 connected to the amplifier output. The amplifier may be a current-driving amplifier or a voltage-driving amplifier.

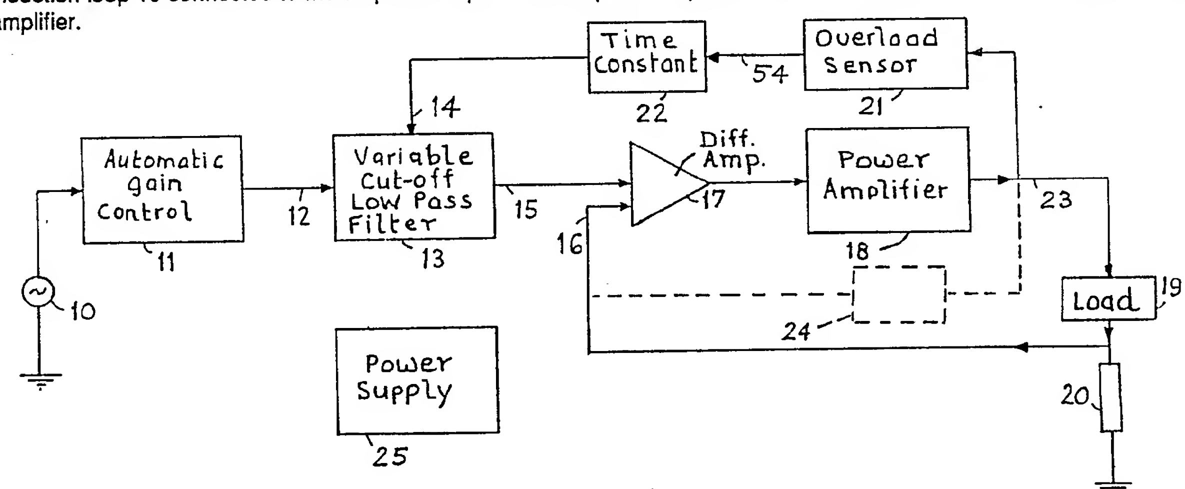

Fig.1

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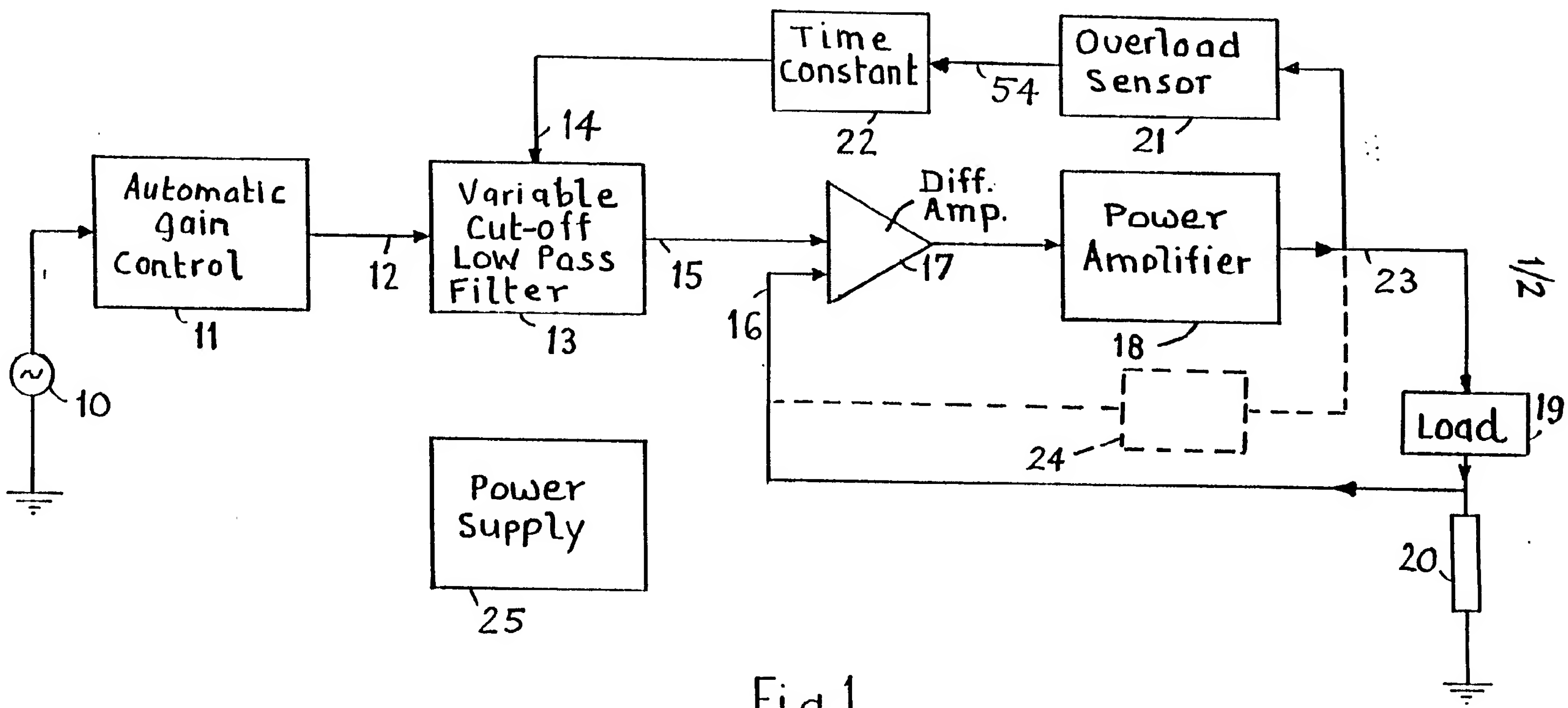

Automatic gain Control
11
10
12
Variable Cut-off Low Pass Filter
13
14
Time Constant
22
54
Overload Sensor
21
15
Diff. Amp.
17
16
Power Amplifier
18
23
24
Load
19
20
Power Supply
25

Fig.1

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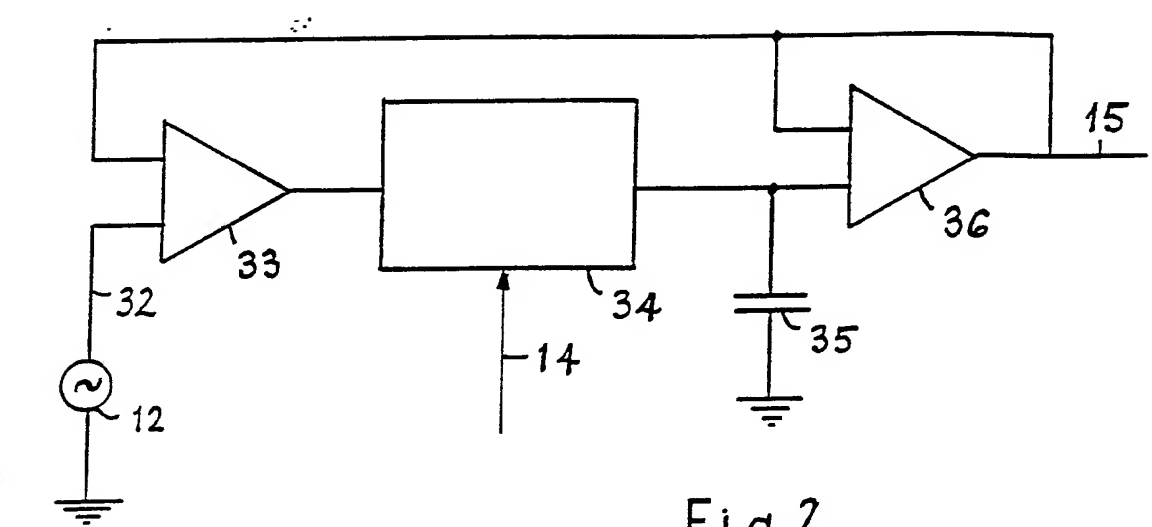

Fig.2

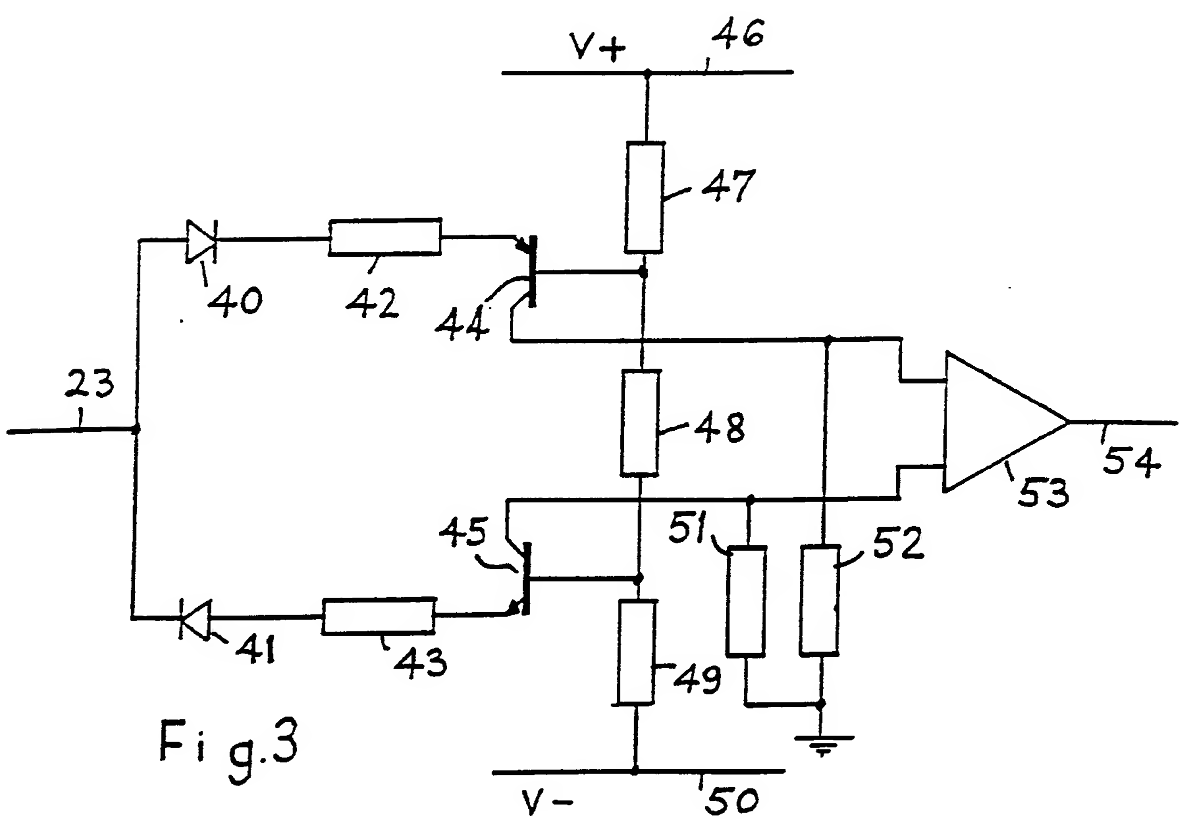

Fig.3

INDUCTION LOOP DRIVING AMPLIFIERS

The present invention relates to amplifiers particularly for driving induction loop systems.

Induction loop systems are used mainly for assisting hearing-impaired people in public places, such as churches, concert halls, theatres and lecture rooms, to hear speech or music without being troubled by the ambient noise generally picked up by the microphone of a hearing aid. With the help of a small pickup coil, often incorporated as standard in modern hearing aids, the user can listen to the originating signal source when an induction loop driving system is installed.

Because of historical constraints, induction loops operate in a mode of constant magnetic field independent of frequency, i.e. constant current is fed into the loop cable. Normal audio amplifiers have been used extensively for feeding the loop but such amplifiers are of a constant voltage nature. Where a loop is connected covering an area of more than 10-20 m^2, the inductance of the wire becomes noticeable at the higher audio frequencies, and for loop sizes of the order of 200 to 500 m^2 the inductance is such as to affect the frequency response in a fairly dramatic manner, resulting in a bandwidth of less than 2 - 3 Khz, with a resulting poor aural performance. High frequency correction networks are sometimes used with normal audio amplifiers in order to compensate for this high frequency loss due to the inductance of the loop. Special power amplifiers have also been built to drive a constant current into such a loop which compensate automatically for the inductive component and

are therefore easier to install and adjust as a substantially level frequency response is obtained without adjustment. However in either case, unless a very powerful unit is used, major radio frequency interference (RFI) can result from high audio frequency components causing the amplifier to saturate thereby clipping the waveform. This waveform with all the harmonics caused by that clipping is fed into a long wire constituting the loop, but this wire also forms a fair radiating aerial for the RFI. Typically a room of 20 x 20 metres needs a current of 8.9 amp applied to the loop in order to obtain a 0.4 A/m field as specified by national standards. Such a loop might have a low frequency resistance of about 2.7 ohm, needing a peak voltage of 24 volts at low frequencies. At 5 Khz the voltage increases to 49.5, while at 10 Khz one needs 79 volts peak, if a level frequency response is to be achieved at full power. Thus, while the volt-amp product at low frequencies is controlled by the resistive losses, the very high volt-amp product at high frequencies is caused by the natural inductance of the loop.

Information has been published internationally on the energy/time distribution of speech and music as a function of frequency. This shows that for a large portion of time the energy in the higher frequencies, which are responsible for speech intelligence, is well below the low and mid-band values. However, for short duration periods, this energy can equal or exceed the mid-band level. Practical experiments indicate that the duration of these periods is sufficient to cause noticeable RFI if the driving amplifier cannot supply the necessary high voltage without limiting the higher frequencies.

The present invention seeks to provide a method for controlling these short duration high energy periods without affecting the normal distribution of the speech and/or music components.

From one aspect the invention consists in an amplifier particularly for an induction loop system wherein means are provided for controlling the amplifier output such that the high frequency response of the amplifier is reduced when a high amplitude high frequency signal component is applied to the input of the amplifier thereby substantially preventing overloading of the amplifier and resultant distortion of the output signal.

From another aspect the invention consists in audio frequency amplifier particularly for feeding an induction loop system wherein the input to said amplifier includes means for controlling the bandwidth of the amplifier in response to the detection of conditions approaching overloading of the amplifier by high amplitude high frequency signal components in such a manner as to reduce the high frequency response of the amplifier during periods when said high amplitude high frequency signal components might otherwise overload the amplifier, thereby substantially avoiding resulting distortion of the amplifier output signal and also the generation of radio frequency interference signals in an induction loop connected to the amplifier output.

The amplifier may be a current-driving amplifier or a voltage-driving amplifier.

The means for controlling the bandwidth of the amplifier advantageously consists of a variable cut-off low pass filter connected in series with the input of the amplifier and controlled by a signal

derived from the output of the amplifier and fed via an overload sensor circuit and a time constant circuit. In a preferred arrangement, the amplifier comprises a difference amplifier feeding a power amplifier and one input of the difference amplifier is fed with the output from the low pass filter. In the case of a current-driving amplifier the other input of the difference amplifier is fed with the signal developed across a current sensing resistor connected in series with the induction loop fed by the output of the power amplifier. Such an arrangement forms a constant current amplifier. In the case of a voltage-driving amplifier the other input of the difference amplifier is fed by a feedback connection from the output of the power amplifier via a resistive attenuator.

The input signal to the variable cut-off low pass filter is preferably fed via an automatic gain control or compression circuit to prevent overloading of the following amplifier stages by the overall input signal applied to the arrangement and which is to be reproduced in amplified form in the induction loop.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a block circuit diagram of one embodiment of amplifier according to the invention for an induction loop,

Figure 2 is a block circuit diagram of a low pass filter as used in the circuit of Figure 1, and

Figure 3 is a block circuit diagram of an overload sensor as used in the circuit of Figure 1.

Referring to Figure 1, a signal source 10, which may be an amplified microphone or any other source of audio signal, is applied via an automatic

gain control circuit 11 to a low pass filter 13 whose cut-off frequency can be rapidly controlled by a signal on a line 14. The output of the filter is applied to a difference amplifier 17 followed by a power amplification stage 18, to drive a load 19 which is an induction loop. A current sensing resistor 20 is connected in series with the loop 19 and an overload sensor 21 has its output fed via a network 22, controlling the attack and decay times of the filter action, to the variable cut-off filter 13.

The automatic gain control circuit 11, also known as a compressor, prevents the overloading of the following stages by the normal input signal, which is generally strongest in the mid-band frequencies. The amplifier stages 17 and 18, combined with resistor 20 and feedback connection 16 form a constant current amplifier, driving a current into the loop 19 which is a replica of the original signal on line 15. The low pass filter 13 can be of any known configuration such as a Bessel or Butterworth arrangement, and only needs to have a roll-off of 6db per octave. The actual implementation of filter 13 can follow any of the accepted filter formats, including switched-capacitor or digital, but a simple and preferred analogue version is illustrated in Figure 2.

As shown in Figure 2 the low pass filter consists of a differential input stage 33, having the output signal 12 from the automatic gain control circuit 11 fed on the non-inverting input, while the signal on output 15 of the filter is applied to the inverting input. The difference signal is applied to the transconductance element 34 in the form of an integrated circuit which appears as a variable resistance under control of the signal from the time

constant network 22 fed over line 14. Combined with capacitor 35, this resistance forms a single-pole RC low pass filter. The output of this filter is buffered by stage 36, and is applied to drive the amplifier stages 17, 18. This configuration may be considered as a classic Butterworth first-order filter as described in the technical literature. In a practical realisation, stages 33 and 34 are normally integrated into a single circuit.

As mentioned before, the control signal applied on line 14 is obtained from the overload sensor 21. A typical embodiment of this sensor is shown in Figure 3. The amplifier output signal on line 23 is compared against a fraction of the supply voltages 46 and 50 powering the amplifier 18. The onset of clipping of this amplifier is generally several volts away from the power supply line, and a sense threshold voltage is set by resistors 47, 48 and 49, ensuring that the transistors 44 and 45 conduct before amplifier 18 limits. The currents in transistors 44 and 45 are fed through resistors 51 and 52 and the resulting voltage is fed to the differential amplifier 53. This ensures that an excursion on line 23 in either positive or negative sense results in a signal of only one polarity on line 54, suitable for applying via time constant network 22, made up of resistors and capacitors, and line 14 to the low pass filter 13.

At low signal levels, the bandwidth of this system is at maximum (typically 10-12Khz in loop applications), but when a high amplitude high frequency component is applied, the feedback applied from line 23 via overload sensor 21 to filter 13 reduces the high frequency response so that amplifier 18 does

not overload. By utilising suitable time constants in network 22, this feedback control can be made fast and stable; and the reduction in bandwidth is often only of some 5-10 milliseconds in duration, with the actual cut-off frequency being dependent on the instantaneous level of the input high frequency components. In other words the rapid dynamic control of the bandwidth of an amplifying stage effectively reduces the high frequency content in a graded manner when amplifier overload is detected. Using the figures quoted above, a practical amplifier need supply no more than some 35 volts peak rather than 79 volts or more, to give normal speech reproduction up to 12 Khz, with barely a noticeable degradation of the intelligence, whilst effectively avoiding generation of radio frequency interference. This represents a substantial saving in amplifier power whilst maintaining a substantially level frequency response.

A similar arrangement may be employed with a voltage-driving amplifier in which case the current sensing resistor 20 is omitted so that the load 19 is connected directly to ground; and instead of the feedback connection 16, a feedback connection is provided from the output 23 of the power amplifier via a resistive attenuator 24 to the other input of the difference amplifier, as shown in broken lines.

A high frequency corrector is also connected between filter 13 and amplifier 17 to compensate for the inductive losses in the load 19.

The power supply for the circuit is indicated at 25.

CLAIMS

1. An amplifier particularly for an induction loop system wherein means are provided for controlling the amplifier output such that the high frequency response of the amplifier is reduced when a high amplitude high frequency signal component is applied to the input of the amplifier, thereby substantially preventing overloading of the amplifier and resulting distortion of the output signal.

2. An audio frequency amplifier particularly for feeding an induction loop wherein the input to said amplifier includes means for controlling the bandwidth of the amplifier in response to the detection of conditions approaching overloading of the amplifier by high amplitude high frequency signal components in such a manner as to reduce the high frequency response of the amplifier during periods when said high amplitude high frequency signal components might otherwise overload the amplifier, thereby substantially avoiding resultant distortion of the amplifier output signal and also the generation of radio frequency interference signals in an induction loop connected to the amplifier output.

3. An amplifier according to claim 2, wherein the means for controlling the bandwidth of the amplifier consists of a variable cut-off low pass filter connected in series with the input of the amplifier and controlled by a signal derived from the output of the amplifier.

4. An amplifier according to claim 3, wherein the signal derived from the output of the amplifier is fed to the low pass filter via an overload sensor

circuit and a time constant circuit.

5. An amplifier as claimed in claim 3 or 4, comprising a difference amplifier feeding a power amplifier and one input of the difference amplifier is fed with the output from the low pass filter whilst the other input of the difference amplifier is fed with a feedback signal from the output of the power amplifier.

6. An amplifier as claimed in claim 5, wherein the feedback signal is developed across a current sensing resistor connected in series with the induction loop fed by the output of the power amplifier, thereby forming a constant current amplifier arrangement.

7. An amplifier as claimed in claim 5 wherein the feedback signal is fed from the output of the power amplifier via a resistive attenuator thereby forming a voltage-driving amplifier.

8. An amplifier as claimed in any of claims 3 to 7, wherein the input signal to the variable cut-off low pass filter is fed via an automatic gain control or compression circuit to prevent overloading of the following amplifier stages.

9. An amplifier as claimed in any of claims 3 to 8, wherein the variable cut-off low pass filter consists of a differential input stage having the input signal fed to its non-inverting input and the signal from the filter output fed to its inverting input, the difference signal being applied to a transconductance element which appears as a variable resistance under control of the signal from the output of the amplifier, and a capacitor connected to the output of the transconductance element.

10. An amplifier as claimed in claim 4, wherein

the overload sensor circuit comprises an arrangement comparing the amplifier output signal as fed to the inductive loop with a fraction of the power supply voltages powering said amplifier.

11. A current driving amplifier particularly for inductive loop systems substantially as hereinbefore described with reference to the accompanying drawings.

12. An inductive loop system including a current driving amplifier as claimed in any preceding claim.

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